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WATER QUALITY AND BIOLOGICAL SURVEY OF FIVE STREAMS IN THE VICINTIY OF STOKES POINT YUKON - BEAUFORT SEA COAST

Regional Program Report No. 84-19

by

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October 1984

ABSTRACT

A baseline inventory of water chemistry, sediment, and biological conditions on five streams near Stokes Point and King Point was undertaken by the Environmental Protection Service. The streams investigated included Deep Creek, Babbage, Trail, Crow, and Spring Rivers. Sampling was conducted in August 1982 and August 1983.

The streams surveyed have been previously categorized as being either a mountain or tundra stream based on the origin of the headwaters region. The water chemistry of mountain streams was typically higher in pH, conductivity, filterable residue, alkalinity and hardness. This difference was further supported by higher concentrations of extractable calcium and magnesium in both the water and sediment samples from mountain streams.

Thirty-five species of benthic invertebrates were identified. Dipterans were the most dominant group both in terms of number of species and number of individuals collected. A new species of amphipod, Synurella sp., was collected. Bottom fauna data indicated that higher densities were associated with clean, gravel substrates and sampling did not show any noticeable differences between the mountain and tundra stream types.

RÉSUMÉ

Un inventaire de base de la chimie de l'eau des sédiment et des conditions biologiques de cinq rivières près du Point Stokes et du Point King fut entrepris par le Service de Protection de l'Environnement. Les rivières examinées comprennent le ruisseau Deep, insi que les rivières Babbage, Trail, Crow et Spring. L'échantillonnage fut mené en août 1982 et août 1983.

Les rivières inventoriées ont été préalablement catégorisées comme étant soit une rivière de montagne ou de toundra, basé sur la région d'où la source origine. La chimie de l'eau des rivières de montagne fut typiquement plus haute pour les mesures de pH, conductivité, résidus filtrables, alkalinité et dureté. Cette différence fut de plus supportée par plus hautes conentrations de calcium et magnésium extractables, tous deux trouvées dans les échantillons d'eau et de sédiments des rivières de montagne.

Trente cinq espèces d'invertébrés benthiques furent identifiées. Les diptères furent le groupe le plus dominant autant en terme de nombre d'espèces que de nombre d'individus récoltés. Une nouvelle espèce d'amphipode, Synurella sp. fut récoltée. Les données de la faune benthique indiquent de plus hautes densités lorsqu'associée avec des substrats de graviers, mais ne démontrant pas de différences perceptibles entre les rivières de montagne et de toundra.

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1 INTRODUCTION

In recent years, the development of Yukon's north coast has been a major concern to governments, private industry, native peoples, and conservation organizations. The most controversial projects have been a deepwater port and shorebase facility proposed by Gulf Canada Resources Inc. at Stokes Point, and a quarry with port facility proposed by Peter Kiewit Sons Ltd. at King Point. Due to the scarcity of biological information at these specific locations, in 1982 the Environmental Protection Service undertook a baseline inventory study at both Stokes Point and King Point (Allan and Mackenzie-Grieve, 1983). This study yielded some interesting results, especially with respect to the benthic invertebrate community at Stokes Point. In order to broaden and increase this data, a follow up survey was conducted in August, 1983.

This study examined five major streams which drain into the Beaufort Sea between Stokes Point and King Point (Figure 1). Two sampling stations were located on each of the streams. Measurements of water quality (temperature, dissolved oxygen, nutrients, extractable metals) and sediment characteristics (particle size, extractable metals, oils and grease) were made. The benthic invertebrate community was also examined at each station.

The 1983 expedition to Yukon's north coast also included a follow-up survey of the coastal waters near Stokes Point. The results are presented in a companion report (Allan and Mackenzie-Grieve, 1984).

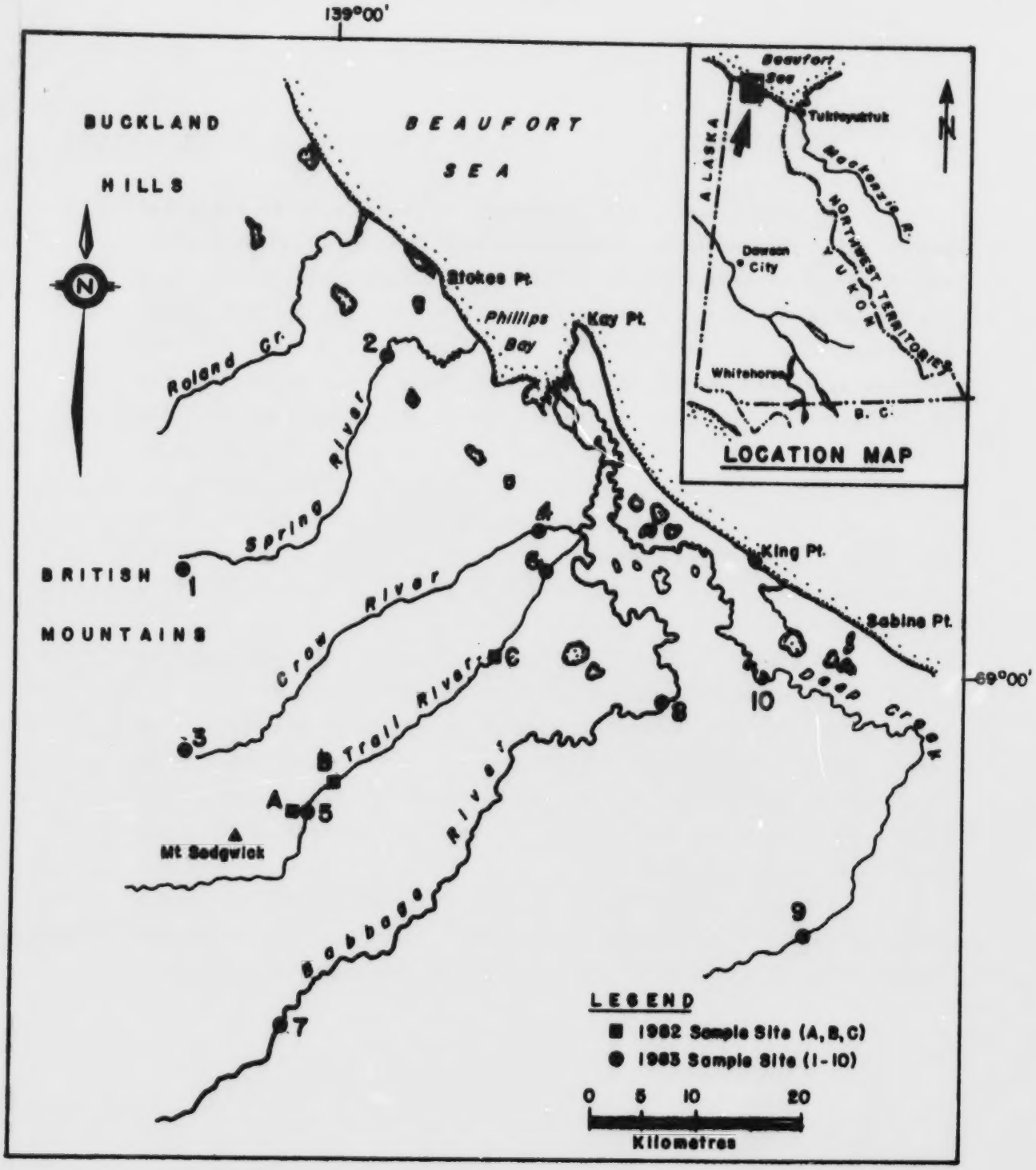

FIGURE 1 LOCATION OF SAMPLING STATIONS

2 STUDY AREA

The study area is located inland of the Beaufort Sea coastline in the British Mountains and on the Yukon Coastal Plain of the Yukon Territory (Figure 1).

Sampling stations were established on five North Slope streams (Figure 1); Spring River (Stations 1 and 2), Crow River (Stations 3 and 4), Trail River (Stations A, B, C, and Stations 5 and 6), Babbage River (Stations 7 and 8), and Deep Creek (Stations 9 and 10). At least two sampling stations were located on each stream; one in the headwaters region and a second in the downstream reaches, approximately 15-35 meters above sea level. Station locations attempted to duplicate where possible, the sampling sites established by McCart et al (1974).

The streams surveyed represent two broad categories of streams as classified by Craig and McCart (1974) being mountain and tundra stream types. Mountain streams originate in the British Mountains and represent the larger rivers in the study area. Watersheds of the tundra streams are confined within the coastal plain region and often extend into the Buckland Hills. Craig and McCart (1974) classified Deep Creek and Spring River as tundra streams and Crow, Trail and Babbage Rivers as mountain streams.

A description of the sampling stations is provided in Table 1 and accompanied by photographs in Figures 2 to 13.

TABLE 1 DESCRIPTION OF SAMPLE SITES IN THE STUDY AREA

STATION	LOCATION	STREAM BOTTOM	REMARKS
1	69°05'N 139°17'W Spring River. Elevation 1500' (450m).	2% gradient, 10% fines, 50% gravels. Floodplain width-80m, 4 active stream channels.	Benthic samples taken in riffle area of a side channel where substrate composition was 80% gravels.
2	69°16'N 138°50'W Spring River. Elevation 50' (15m).	0.5% gradient, 20% fines, 80% gravels. Floodplain width-50m, wetted width-20m.	Benthic samples taken in riffle area where gravels composed 60% of substrate.
3	68°56'N 139°16'W Crow River. Elevation 1000' (300m).	1.0% gradient, 60% gravels, 40% cobbles. Floodplain width-100m, wetted width-30m.	Benthic samples taken in 3m wide side channel. Suitable sediment sample difficult to find due to low composition of fines.
4	69°07'N 138°28'W Crow River. Elevation 50' (15m).	0.5% gradient, 20% fines, 70% gravels. Floodplain width-400m, braided channels.	Benthic samples taken in riffle area of a smaller channel.
5,A	68°54'N 139°00'W Trail River. Elevation 750' (230m).	1.0% gradient, 10% fines, 30% gravels. Floodplain width-120m, wetted width-25m.	Benthic samples taken in a coarse gravel substrate. 2 cm fish observed.

TABLE 1 DESCRIPTION OF SAMPLE SITES IN THE STUDY AREA (continued)

STATION	LOCATION	STREAM BOTTOM	REMARKS
6	69°06'N 138°04'W Trail River. Elevation 50' (15m).	1.0% gradient, 10% fines, 50% gravels. Floodplain width-120m, wetted width-30m.	Benthic samples taken from main channel.
7	68°43'N 139°04'W Babbage River. Elevation 700' (215m).	1.0% gradient, 80% gravels, 20% cobbles. Floodplain width-100m, wetted width-30m.	200m downstream of 5m waterfall. Benthic samples taken from riffle section.
8	68°59'N 138°12'W Babbage River. Elevation 120' (35m).	0.5% gradient, 70% gravels, 30% cobbles. Floodplain width-150m, wetted width-60m.	Experienced difficulty in obtaining benthic samples due to coarse substrate.
9	68°48'N 137°53'W Deep Creek. Elevation 500' (150m).	0.5% Gradient, 90% gravels, 10% cobbles. Floodplain width-8m, wetted width-4m.	Clean gravels with low compaction. Well vegetated streambanks.
10	69°01'N 137°58'W Deep Creek. Elevation 70' (20m).	0.2% gradient, 90% fines, 10% gravels. Floodplain width-30m, wetted width-20m.	Slow, meandering stream section.

FIGURE 2 STATION 1. LOCATED IN THE HEADWATER REGION OF THE SPRING RIVER WITHIN THE BUCKLAND HILLS.

FIGURE 3 STATION 2. LOCATED ON A WIDE SWEEPING MEANDER OF THE SPRING RIVER IN THE COASTAL PLAIN REGION. PERMAFROST STREAMBANKS ARE ACTIVELY SLUMPING INTO THE STREAM CHANNEL.

FIGURE 4 STATION 3. LOCATED IN THE HEADWATER REGION OF THE CROW RIVER WITHIN THE BRITISH MOUNTAINS.

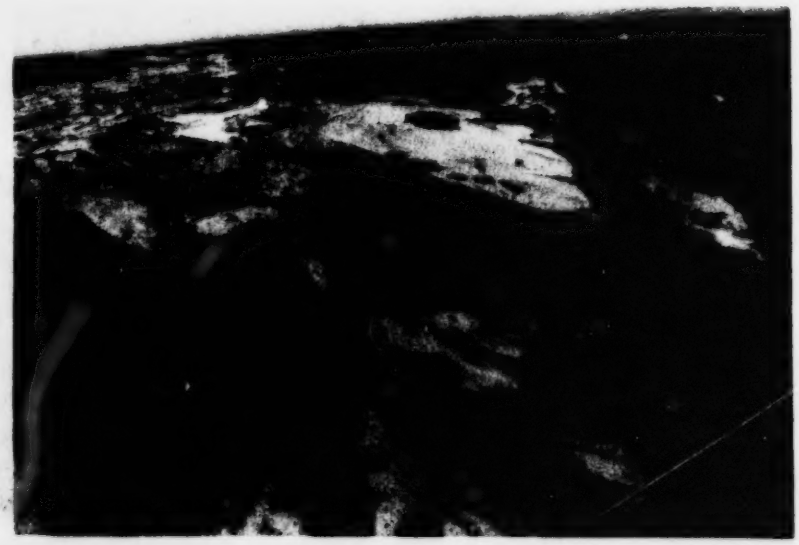

FIGURE 3 STATION 4. LOCATED IN A BRAIDED SECTION OF THE CROW RIVER ON THE COASTAL PLAIN.

FIGURE 6 STATION 5. LOCATED IN THE CENTRAL REGION OF THE TRAIL RIVER IN THE BRITISH MOUNTAINS.

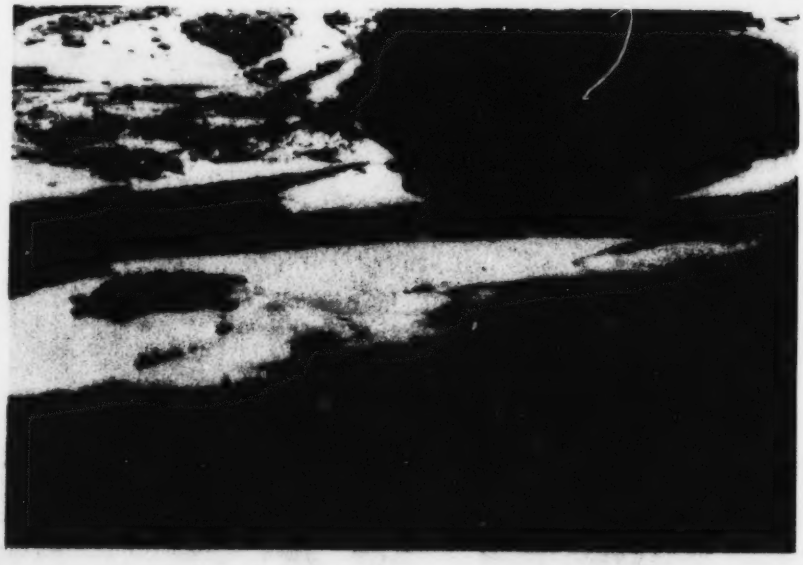

FIGURE 7 STATION 6. LOCATED ON THE LOWER REACHES OF THE TRAIL RIVER ON THE COASTAL PLAIN.

FIGURE 8 STATION 7. LOCATED 200 METRES DOWNSTREAM OF A 5 m HIGH WATERFALL ON THE BABBAGE RIVER.

FIGURE 9 - AERIAL VIEW OF THE BABBAGE RIVER CANYON AND STATION 7.

FIGURE 10 STATION 8. LOCATED IN THE LOWER REACHES OF THE BABBAGE RIVER.

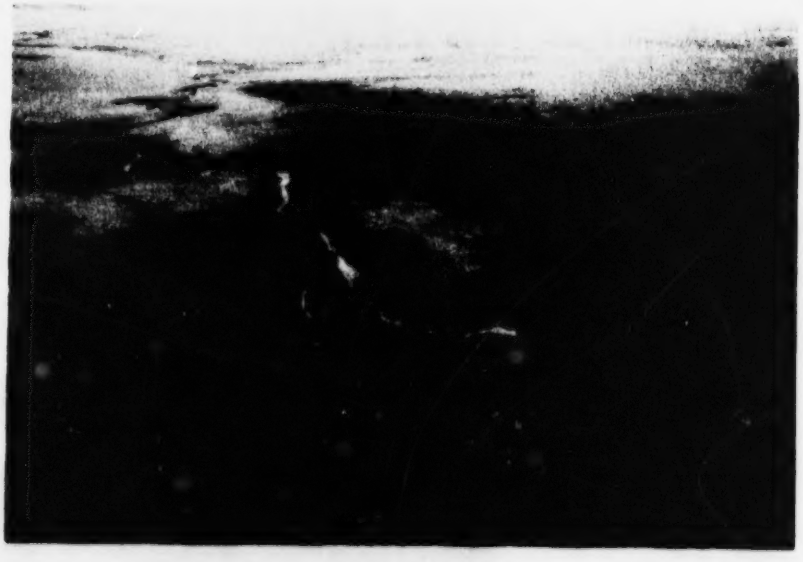

FIGURE 11 AERIAL VIEW OF THE HEADWATERS REGION OF DEEP CREEK, A TUNDRA STREAM, AT STATION 9.

FIGURE 12 STATION 9. LOCATED ON UPPER REACHES OF DEEP CREEK.

FIGURE 13 STATION 10. LOCATED IN THE CENTRAL PORTION OF DEEP CREEK, NEAR KING POINT.

3 METHODS

Field work was conducted on August 6, 1982 and August 6 and 7, 1983. A helicopter was used to access all of the sampling stations.

3.1 Water Quality

Water chemistry data was collected and analysed as described in Appendix 1, Table 1.

The parameters measured in the field included flow, temperature, conductivity, dissolved oxygen, and pH. The flow measurements were estimated and are therefore, very approximate. Dissolved oxygen measurements were compensated in the field for in situ temperature and atmospheric pressure. Solubility tables from APHA et al (1981) were used to calculate percent dissolved oxygen saturation. Results for the field measurement of pH are incomplete due to the pH meter becoming unserviceable during field work.

A 1 litre water sample was collected for determination of non-filterable residue content. This water sample was filtered through a pre-weighed, 1.5 um glass fibre filter in the field. The filter was folded, then sealed in tin foil, placed on dry ice and subsequently analyzed at the Environmental Protection Service Laboratory in Whitehorse.

Water samples for nutrient and extractable metal analysis were collected and subsequently analyzed at the Environmental Protection Service Laboratory in West Vancouver, British Columbia. The sample for nutrients was collected in a two-litre polyethylene container and kept cool throughout transportation. The sample for extractable metals was collected in a 200 ml polyethylene container and preserved with concentrated nitric acid.

3.2 Sediment

Three sediment samples were collected at each station using an aluminum scoop shovel. Samples were placed into geochemical sample

bags and then inside plastic Whirlpack™ bags. Samples were immediately frozen on dry ice and maintained at a cool temperature throughout transport.

The sediment samples were analyzed for extractable oils and grease, extractable metals, and particle size at the Environmental Protection Service Laboratory in West Vancouver, B.C. A description of the sediment sample preparation and analysis is shown in Appendix 1, Table 2.

3.3 Bottom Fauna

Bottom fauna samples were collected using a Surber Sampler (0.09 m^2) with a mesh opening size of 0.363 mm. Three replicates were taken at each station representing a total sample area of 0.27 m^2.

Bottom fauna samples were initially preserved in a 10% formalin solution and later transferred into a 70% methanol solution after debris separation. Samples were identified and enumerated by Dr. Charles J. Low, a consulting biologist, in Nanaimo, British Columbia. Dr. Low conferred with Mr. Ed Bousfield of the National Museums of Canada in Ottawa, Ontario, for identification of an amphipod.

To numerically compare the invertebrate data, diversity and evenness indices were calculated using the following formulae as described by Pielou (1975):

$$\text{Species Diversity } (H') = -\sum_{i=1}^{g} (P_i \log_{10} P_i)$$

where $P_i = n_i/N$

n_i = total number of individuals in the ith genus in one sample

N = total number of individuals identified to genus and/or species taxonomic level in one sample

g = total number of genera in one sample

$$\text{Evenness } (J') = H'/\log g$$

4. RESULTS AND DISCUSSION

4.1 Water Quality

The water chemistry data and concentrations of extractable metals are presented in Appendix II, Tables 1 and 2, respectively. The data collected from Trail River on August 6, 1982 did not include extractable metals analysis.

In review of the water chemistry data (Appendix II, Table 1), the tundra streams (Stations 1, 2, 9 and 10) revealed consistently lower pH (7.2 to 7.8), conductivity (95 to 135 umhos/cm), filterable residue (102 to 136 mg/l), alkalinity (17.5 to 70 mg/l), and hardness (58.6 to 99.2 mg/l). The higher pH, conductivity, filterable residue, alkalinity, and hardness associated with the mountain streams reflect the nature of the limestone bedrock in which the streams originate (Craig and McCart, 1974). Stations 9 and 10 (Deep Creek) recorded consistently lower values in these parameters than Stations 1 and 2 (Spring River). Stations 5 and 6 (Trail River) were consistently higher than the other stations in these parameters. The upstream station on Crow River (Station 3) and the downstream station on the Babbage River (Station 8) were consistently lower in these parameters when compared to their companion stations. The comparative analysis of these parameters; pH, conductivity, filterable residue, alkalinity, and hardness; reflects the relative presence of the British Mountains physiographic unit in the respective stream's watershed and the interaction with tundra tributary streams (Craig and McCart, 1974). Streams having high values in these parameters would have a correspondingly high percentage of their watershed in the British Mountains.

Dissolved oxygen levels were all high (>85%) which is typical of unpolluted, flowing water during the summer period. The 111% saturation observed at Station 7 reflects the aeration affect that the canyon and waterfall located immediately upstream has on dissolved oxygen levels (Figure 8).

Non-filterable residue levels were generally <5 mg/l at upstream stations and slightly higher at the downstream stations with exception of Stations 7 and 8. Station 10 showed the highest values for colour, turbidity, total phosphates, ammonia, and chloride. Deep Creek fits the criteria of a tundra stream as defined by Craig and McCart (1974) who indicate that tundra streams are typically stained brown, have lower concentrations of calcium and magnesium and a lower alkalinity, pH and conductivity than mountain streams of the Yukon north slope.

The results obtained from the extractable metals analysis (Appendix II, Table 2) have been compared to recommended levels for drinking water and aquatic life, which are summarized in Appendix I, Table 3. Recommended levels for drinking water and aquatic life are usually expressed as total metals whereas our results are given as extractable metals. Levels for extractable metals will be less than total metals for a particular sample, however in samples with low NFR values the results will in practice be very similar.

Concentrations of aluminum at Stations 2, 8 and 10 slightly exceeded the recommended level for aquatic life. Turbidity at Station 10 and colour at Stations 2 and 10 slightly exceeded the recommended levels for drinking water. Concentration of iron also exceeded the drinking water limits at Stations 2 and 10. All other parameters were safely below the recommended guidelines. A general trend observed was that levels of aluminum, iron, potassium, manganese, and sodium increased at all downstream locations.

The metals which had concentrations (extractable) at or below the detection limit included; silver (.0005 mg/l), arsenic (.0005 mg/l), boron (.001 mg/l), beryllium (.001 mg/l), cadmium (.0005 mg/l), cobalt (.005 mg/l), chromium (.005 mg/l), copper (.001 mg/l), molybdenum (.005 mg/l), nickel (.02 mg/l), phosphorous (.05 mg/l), lead (.001 mg/l), antimony (.05 mg/l), selenium (.05 mg/l), tin (.01 mg/l), titanium (.002 mg/l), vanadium (.01 mg/l), and zinc (.002 mg/l). The most abundant element present in the water was calcium (range 14.3 to

60.7 mg/l). Magnesium (4.0 to 9.6 mg/l), sodium (0.3 to 5.3 mg/l), and silica (1.2 to 1.8 mg/l) were also present in noticeable quantities.

The highest levels of iron and potassium were observed at Stations 2 and 10 which were the downstream locations in the tundra streams. The mountain streams when compared to the tundra streams were typically higher in concentrations of calcium and magnesium.

4.2 Sediments

The results of the sediment particle size analysis are presented in Appendix III, Tables 1a and 1b. Most samples had a low percentage of fine textured material and a high percentage of gravel size particles although exceptions are noted at Station 3 and two replicates at Station 1. Station 4 had the highest quantity of fine material with up to 32% less than .15 mm particle size in one subsample. Obtaining truly representative substrate samples with the method used is unlikely since some of the fines are lost in the current during sampling and the larger boulders are not included in representative proportions in the sample. Only the smaller than .15 mm particle size component was analyzed for extractable metals.

The results of the oils and grease, and extractable metal analysis, are presented in Appendix III, Tables 2a and 2b. The results of the oils and grease analysis vary due to the analytical procedures however no elevated levels were observed in the samples from 1982 or 1983.

The results of the extractable metals analysis were compared for general purposes to values in several other Yukon streams as reported in Mathers et al (1981). The concentrations of cadmium, iron, manganese, molybdenum, sodium, silica, tin, and zinc were comparable. Aluminum, barium, calcium, mercury, and strontium were similar, but slightly higher in range; while chromium, copper, magnesium, sodium, phosphorous, lead, and vanadium were similar, but slightly lower in range.

The tundra streams, Stations 1, 2, 9 and 10 were considerably lower in sediment concentrations of calcium, magnesium, and phosphorous. This data supports the differences in water chemistry parameters, such as lower hardness, and relates to the varying geological features of the watersheds for tundra and mountain streams.

The data collected on Trail River (Station A) (Appendix III, Table 2a) in 1982 was compared to 1983 data (Station 5) since the sample locations is the same. The 1983 data revealed higher cobalt, lead, and silica concentrations and lower potassium and sodium values. The sodium values observed in the 1982 data was considerably higher. This difference probably respresents natural and sampling variability since there are no apparent disturbances in the area.

4.3 Bottom Fauna

A taxonomic list outlining the organisms collected is presented in Appendix IV, Table 1. The results of the bottom fauna survey are provided in Appendix IV, Table 2.

Three replicate samples with the Surber Sampler were collected at each station (0.27 m^2 total sample area). Individual samples were combined into one composite sample representing each station.

Forty-three different organisms were collected from the ten sampling stations. Thirty-five organisms were identified to the genus level. The most diverse order represented in terms of number of species was Diptera, with twenty species being identified. The most abundant groups, as represented by number of individuals collected were Diptera (32%), Ephemeroptera (27%), Plecoptera (16%), Amphipoda (11%), and Oligochaeta (8%). The species most abundantly represented were Synurella sp., Podmosta sp., Baetis sp., Eukiefferiella sp., and Cricotopus sp.

There were two unusual species identified in the samples. The amphipod, Synurella sp., has been identified by Mr. E.L. Bousfield (Pers. Comm.) as a new species and has been added into the National

TABLE 2 SUMMARY OF THE BOTTOM FAUNA DATA

STATION	NUMBER OF SPECIES PRESENT	DIVERSITY (H')	EVENNESS (J')	DENSITY (no./m^2)
1	16	.49	.44	3060
2	16	.89	.80	450
3	20	.83	.69	700
4	21	.56	.45	2510
5	13	.59	.59	490
6	15	.80	.74	410
7	19	.81	.71	740
8	10	.64	.82	160
9	12	.90	.94	1740
10	14	.58	.61	530

Collection of Crustacea at the National Museum of Canada, Ottawa. The Synurella sp. was found in considerable abundance at the upstream station on Deep Creek (Station 9) as well as being present in the Crow River (Station 3). Bousfield, 1984 (Pers. Comm.) indicated that the Synurella is the first record of this genus in Canada and may be the most northerly location on record.

Another species of interest was the dipteran, Paraphrosylus sp., which was found at Station 4, the downstream station on Crow River. Dr. Low (pers. comm.) commented that Paraphrosylus sp. is recognized as an intertidal species, however, the sample location was approximately 15 meters above sea level and 25 kilometers from salt-water. Therefore, the identification is most likely incorrect.

Table 2 presents a summary of the bottom fauna data. The numbers of species per station varied from 10 at Station 8 to 21 at Station 4. The Shannon-Weaver diversity index values ranged from 0.49 at Station 1 to 0.90 at Station 9. Evenness values varied from 0.44 at Station 1 to 0.94 at Station 9 as shown in Table 2. Population density was lowest at Station 8 (160 organisms/meter^2) and highest at Station 1(3060/m^2).

There is considerable variation in factors such as stream gradients, flow, and substrate composition among the sample locations as well as basic differences between tundra and mountain streams as described by Craig and McCart (1974) which contribute to natural variability of the benthos. No trends or patterns can be observed in the data that relate to an observable environmental condition. It is suggested that much more intensive sampling of the streams would be required to specifically characterize the benthic fauna in headwater versus downstream reaches or tundra versus mountain streams.

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APPENDICES

APPENDIX I

COLLECTION, PREPARATION, AND ANALYSIS METHODS OF WATER AND SEDIMENT SAMPLES

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PREPARATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Temperature	0.1°C	In situ measurement.	YSI Model 33 Conductivity Meter	
Conductivity	0.2 umhos/cm	In situ measurement. Lab measurement was taken from the same sample as NH_3 below.	YSI Model 33 Conductivity Meter Radiometer Conductivity Meter (CDMC)	044
Dissolved Oxygen	1.0 mg/l	In situ measurement. The instrument was calibrated in the field under water saturated air conditions.	YSI Model 57 Dissolved Oxygen Meter	
pH		Small aliquots of sample were measured soon after collection. Instrument was calibrated using 7.0 buffering solution.	Potentiometric	080
Non-Filterable Residue (NFR)	5.0 mg/l	Sample was filtered through a pre-weighed glass fibre filter with a 1.5 um pore size.	Filtration, Drying And Weighing Of Residue On Filter	104
Filterable Residue (FR)	10.0 mg/l	Same sample as NH_3.	Filtration, Drying And Weighing Of Filtrate	100

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Ammonia NH_3-N	0.005 mg/l	Single samples collected in 2 litre linear polyethylene containers. Each container was rinsed 3 times with sample before it was filled. No preservatives. Stored at 4°C.	Phenol Hypochlorite-Colorimetric-Automated	058
Colour	5 (colour units)	Same sample as NH_3.	Platinum-Cobalt Visual Comparison	040
Turbidity	0.1 (FTU)	Same sample as NH_3.	Nephelometric Turbidity	130
Total Alkalinity	1.0 mg/l as $CaCO_3$	Same sample as NH_3.	Potentiometric Titration	006
Total Phosphate T PO_4-P	0.005 mg/l	Same sample as NH_3.	Acid-persulphate, Autoclave Digestion	086
Nitrite NO_2-N	0.005 mg/l	Same sample as NH_3.	Diazotization-Colorimetric-Automated	070
Nitrate NO_3-N	0.01 mg/l	Same sample as NH_3.	Cadmium Copper Reduction Colorimetric Automated	072
Sulphate SO_4	1.0 mg/l	Same sample as NH_3.	Barium Chloranilate -UV Spectrophotometric	122
Chloride Cl	0.5 mg/l	Same sample as NH_3.	Thiocyanate-Combined Reagent-Colorimetric	024

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Extractable Metals	mg/l	Single samples collected in 200 ml linear polyethylene bottles. Each bottle was rinsed 3 times with sample before filling. Preserved to a pH <1.5 using 2.0 ml concentrated HNO_3.	Inductively Coupled Argon Plasma (ICAP) combined with Optical Emission Spectrometer (OES)	300
Al	0.05			
As	0.05			
B	0.001			
Ba	0.001			
Be	0.001			
Ca	0.1			
Cd	0.002			
Co	0.005			
Cr	0.005			
Cu	0.005			
Fe	0.005			
Mg	0.10			
Mn	0.001			
Mo	0.005			
Na	0.5			
Ni	0.02			
P	0.05			
Pb	0.02			
Sb	0.05			
Se	0.05			
Si	0.1			
Sn	0.01			
Sr	0.001			
Tl	0.002			
V	0.01			
Zn	0.002			

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
As	0.00050	Same sample as metals.	Hydride Generation - ICAP	350
Cd	0.0005	Same as sample metals.	Graphite Furnace Atomic Absorption Spectrophotometry	330
Cu	0.001	Same sample as metals.		
Pb	0.001	Same sample as metals.		
Ag	0.0005	Same sample as metals.		
K	0.01 mg/l	Same sample as metals.	Flame Atomic Absorption Spectrophotometry	340
Total Hardness	0.030 mg/l as $CaCO_3$	Same sample as metals.	The sum of the ICAP results for Mg x 4.116 and Ca x 2.497 reported as mg/l $CaCO_3$	

1 As described in Environment Canada (1976).

2 As described in Department of Environment (1979).

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	COLLECTION/PREPARATION	ANALYSIS	METHOD CODE[1]
All Parameters	Samples were collected and placed in geochemical sampling bags within Whirlpack™ bags. Samples were frozen and kept cool through transportation. No preservatives were required.		
Extractable Metals Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, P, Pb, Sl, Sn, Sr, Ti, V, Zn	A sediment sample was dried in a low temperature oven then screened through a 100 mesh (0.15 mm) sieve. The material passing through the sieve was then leached with HCl and HNO_3.	Inductively Coupled Argon Plasma (ICAP) combined with Optical Emission Sepctrometer (OES)	320
Ag	Same sample as metals.	Graphite Furnace Atomic Absorption Spectrophotometry	330
K	Same sample as metals.	Flame Atomic Absorption Spectrophotometry	340
As	Same sample as metals.	Hydride Generation - ICAP	350
Hg	The sample was selved as described for metals and was completely oxidized by digestion with sulfuric acid peroxide.	Mercury Monitor	370

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	COLLECTION/PREPARATION	ANALYSIS	METHOD CODE[1]
Particle Sizing	A dry, pre-weighed sample was passed through a series of selves.	Dry sieve	078
Oils and grease	A sample of air dried sediment was placed in the Soxhlet apparatus with petroleum ether solvent. The solvent dissovles the oils and grease which is then evaporated and the residue weighed.	Petroleum ether Soxhlet Extraction	725

[1] As described in Department of Environment (1979).

APPENDIX I TABLE 3 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Alkalinity mg/l (Total)	Not considered a public health problem	4	>20	3
Aluminum (Al) mg/l	Not considered a public health problem	7	0.1	5
Ammonia (NH_3-N) mg/l	0.5	4	0.02	3
Arsenic (As) mg/l	0.05	1	0.05	2
Barium (Ba) mg/l	1.0	1	5.0	7
Cadmium (Cd) mg/l	0.005	1	0.0002	2
Calcium (Ca) mg/l	75-200	7		
Chloride (Cl) mg/l	250	1		
Chromium (Cr) mg/l	0.05	1	0.04	2
Colour Pt. Counts	15	1		
Conductivity @ 25°C (umhos/cm)	Depends on dissolved salts	7	150-500	6
Copper (Cu) mg/l	1.0	1	0.005	5
Dissolved oxygen (% saturation)	Near 100%	4	$\geq$5.0 mg/l	3
Hardness (Total) as mg/l $CaCO_3$	80-100	1		
Iron (Fe) mg/l	0.3	1	1.0	3
Lead (Pb) mg/l	0.05	1	0.005 (soft H_2O*)	2
			0.01 (hard H_2O*)	2
Magnesium (Mg) mg/l	50	4		
Manganese (Mn) mg/l	0.05	1	1.0	7
Nickel (Ni) mg/l	0.25	2	0.025 (soft H_2O*)	2
			0.25 (hard H_2O*)	2
Nitrate (NO_3-N) mg/l	10	1		
Nitrite (NO_2-N) mg/l	0.001	1		
pH units	6.5 - 8.5	1	6.5 - 9.0	3
Phosphorus (P) mg/l (Total)			0.020 to prevent algae	5

APPENDIX I TABLE 3 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Residue: Filterable mg/l (Total dissolved solids)	1000	4	70 - 400 with a maximum of 2000	6
Selenium (Se) mg/l	0.01	1	0.01	2
Silver (Ag) mg/l	0.05	1	0.0001	2
Sodium (Na) mg/l	20	1		
Strontium (Sr) mg/l	10	1		
Sulphate (SO_4) mg/l	500	1		
Tin (Sn) mg/l	Not present in natural waters	7		
Turbidity J.T.U.	5	1		
Zinc (Zn) mg/l	5.0	1	0.030	5

* Soft water has a total hardness less than 95 mg/l as $CaCO_3$. Hard water has a total hardness of more than 95 mg/l as $CaCO_3$ (Reference 6).

REFERENCES:

1. Health & Welfare Canada, Guidelines for Canadian Drinking Water Quality 1978, Supply and Services, Canada (1979).

2. Inland Waters Directorate, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances. Environment Canada, Ottawa (1979, 1980).

3. Thurston, R.V., R.C. Russo, C.M. Fetteroff Jr., T.A. Edsall, and Y.M. Barber Jr. (Eds.), A Review of the EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD, 313p. (1979).

APPENDIX I TABLE 3 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)

4. Anonymous, Guidelines for Establishing Water Quality Objectives for the Territorial Waters of the Yukon and Northwest Territories. Report of the Working Group on Water Quality Objectives to the Chairmen, Water Boards, Yukon and Northwest Territories, July (1977).

5. Ontario Ministry of the Environment, Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. (1978).

6. Environment Canada, Pollution Sampling Handbook. Pacific Region Laboratory Services, Fisheries Operations and Environmental Protection Service, West Vancouver, B.C. (1976).

7. California State Water Resources Control Board, Water Quality Criteria. Publication No. 3-A Second Edition by McKee and Wolf. (1963)

APPENDIX II

WATER QUALITY DATA

APPENDIX II TABLE 1 WATER CHEMISTRY DATA

STATION NUMBER	DATE	TIME	FLOW* m^3/s	TEMP (°C)	D.O. (mg/l)	D.O. SATURATION (%)	IN SITU pH	LAB pH	IN SITU COND. (umhos/cm)	LAB COND. (umhos/cm)	COLOUR (colour units)	TURBIDITY (FTU)
1	83/8/6	1150	.4	8.5	10.7	91	8.0	7.8	135	208	<5	0.1
2	83/8/6	1040	1.0	10.5	10.4	93	7.8	7.7	130	195	<5	8.0
3	83/8/6	1300	3.6	9.5	9.6	84	8.2	7.9	145	214	<5	0.5
4	83/8/7	1230	20	11.0	10.6	96	-	8.0	210	293	<5	3.4
5	83/8/6	1350	1.0	10.8	10.0	90	8.5	8.0	230	333	<5	0.2
6	83/8/7	1200	4.8	10.5	10.8	97	-	8.0	240	347	<5	0.8
7	83/8/6	1500	12	10.5	12.4	111	-	8.1	200	290	<5	3.0
8	83/8/7	1100	30	12.0	10.7	99	-	7.9	195	264	10	3.8
9	83/8/6	1630	.4	12.5	9.8	92	-	7.2	95	135	10	0.8
10	83/8/7	1000	1.6	12.5	9.9	93	-	7.4	95	138	40	8.5
A	83/8/6	1545	4	8.9	-	-	-	8.1	-	323	8	0.3
B	83/8/6	1625	4	11.1	-	-	-	8.2	-	312	15	0.6
C	83/8/6	1720	4	11.9	-	-	-	8.1	-	307	15	1.0

* Very rough estimate.

APPENDIX II TABLE 1 WATER CHEMISTRY DATA (continued)

STATION NUMBER	FIELD NFR (mg/L)	LAB NFR (mg/L)	F.R. (mg/L)	TOTAL ALKALINITY (mg/L $CaCO_3$)	TOTAL HARDNESS (mg/L $CaCO_3$)	TOTAL PO_4-P (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	NH_3-N (mg/L)	SO_4 (mg/L)	Cl (mg/L)
1	<5	5	136	70.0	99.2	<.005	<.005	.08	<.005	32.2	0.7
2	13.3	13	135	62.5	93.4	.016	<.005	.04	.005	32.0	1.5
3	<5	5	144	84.0	108	<.005	<.005	.04	<.005	26.1	0.5
4	11.9	11	198	107	149	.016	<.005	.04	<.005	45.0	0.6
5	<5	<5	218	130	174	<.005	<.005	.07	<.005	44.0	0.7
6	<5	<5	230	130	177	.007	<.005	.05	<.005	54.0	0.8
7	10.3	13	188	122	153	.010	<.005	.06	<.005	29.5	0.7
8	5.2	7	180	71.0	128	.009	<.005	.03	.006	61.0	0.6
9	<5	<5	102	17.5	59.5	.005	<.005	.01	<.005	44.0	<0.5
10	5.8	12	112	58.0	58.6	.025	<.005	.01	.017	15.8	2.2
A	--	--	--	126	--	.010	<.005	.063	<.005	11.5	0.8
B	--	--	--	126	--	.007	<.005	.058	<.005	8.5	0.7
C	--	--	--	124	--	.008	<.005	.005	<.005	39.4	0.7

APPENDIX II TABLE 2 CONCENTRATION OF EXTRACTABLE METALS IN WATER SAMPLES

STATION NUMBER	EXTRACTABLE METALS (mg/L)													
	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Mg
1	<.0005	<.05	<.0005	.005	.028	<.001	30.3	<.0005	<.005	<.005	<.001	.007	.309	5.6
2	<.0005	.15	<.0005	.006	.047	<.001	28.7	<.0005	<.005	<.005	.001	.398	.684	4.9
3	<.0005	.06	<.0005	.006	.033	<.001	34.1	<.0005	<.005	<.005	<.001	.081	.274	5.3
4	<.0005	.1	<.0005	.006	.031	<.001	48.6	<.0005	<.005	<.005	.001	.217	.398	6.5
5	<.0005	<.05	<.0005	.005	.037	<.001	59.9	<.0005	<.005	<.005	<.001	.040	.22	5.8
6	<.0005	.06	<.0005	.006	.035	<.001	60.7	<.0005	<.005	<.005	<.001	.103	.388	5.9
7	<.0005	.09	<.0005	.005	.035	<.001	47.1	<.0005	<.005	<.005	<.001	.157	.335	8.4
8	<.0005	.17	<.0005	.006	.025	<.001	34.6	<.0005	<.005	<.005	<.001	.255	.486	9.6
9	<.0005	.06	<.0005	.006	.022	<.001	14.3	<.0005	<.005	<.005	<.001	.174	.351	5.6
10	<.0005	.19	<.0005	.006	.071	<.001	15.6	<.0005	<.005	<.005	.002	.947	.758	4.0

APPENDIX II TABLE 2 CONCENTRATION OF EXTRACTABLE METALS IN WATER SAMPLES

STATION NUMBER	EXTRACTABLE METALS (mg/L)													
	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	Sn	Sr	Ti	V	Zn
1	<.001	<.005	.6	<.02	<.05	<.001	<.05	<.05	1.2	<.01	.16	.002	<.01	<.002
2	.013	<.005	1.5	<.02	<.05	<.001	<.05	<.05	1.5	<.01	.122	.004	<.01	<.002
3	.003	<.005	.3	<.02	<.05	<.001	<.05	<.05	1.2	<.01	.112	.003	<.01	.003
4	.012	<.005	.6	<.02	<.05	<.001	<.05	<.05	1.3	<.01	.193	.003	<.01	<.002
5	.002	<.005	.6	<.02	<.05	<.001	<.05	<.05	1.2	<.01	.132	.002	<.01	<.002
6	.012	<.005	.7	<.02	<.05	<.001	<.05	<.05	1.2	<.01	.131	<.002	<.01	<.002
7	.002	<.005	1.3	<.02	<.05	<.001	<.05	<.05	1.8	<.01	.123	<.002	<.01	<.002
8	.049	<.005	1.7	<.02	<.05	<.001	<.05	<.05	1.6	<.01	.115	.003	<.01	.006
9	.014	<.005	.8	<.02	<.05	<.001	<.05	<.05	1.4	<.01	.065	.003	<.01	<.002
10	.04	<.005	5.3	<.02	<.05	<.001	<.05	<.05	1.3	<.01	.122	.007	<.01	.003

APPENDIX III

SEDIMENT DATA

APPENDIX III TABLE 1a PERCENT COMPOSITION OF PARTICLE SIZE FRACTIONS IN SEDIMENT SAMPLES COLLECTED FROM TRAIL RIVER ON AUGUST 6, 1982

SAMPLE NUMBER	PARTICLE SIZE (mm)					
	<.075	.075-.15	.15-.30	.30-1.18	1.18-2.36	>2.36
	SILT	VERY FINE SAND	FINE SAND	COARSE SAND	VERY COARSE SAND	GRAVEL
A-1	0.2	0.2	0.4	11.6	9.9	77.6
A-2	0.2	0.1	0.9	0.2	1.3	97.3
A-3	0.3	0.2	0.6	17.4	11.7	69.9
B-1	0.2	0.3	1.9	56.2	27.1	14.2
B-2	0.2	0.3	1.9	62.8	21.1	13.7
B-3	0.2	0.4	3.4	72.6	16.8	6.6
C-1	5.4	14.8	58.4	16.7	1.3	3.5
C-2	2.4	5.2	36.1	29.7	2.1	24.5
C-3	2.7	8.4	36.8	22.3	2.2	27.7

APPENDIX III TABLE 1b PERCENT COMPOSITION OF PARTICLE SIZE FRACTIONS IN SEDIMENT SAMPLES COLLECTED AUGUST 6 AND 7, 1983

SAMPLE NUMBER	PARTICLE SIZE (mm)					
	<.063	.063-.15	.15-.25	.25-.5	.5-1.0	>1.0
	SILT	V. FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL
1-1	0.3	1.4	2.6	4.9	7.8	83.0
1-2	0.4	2.2	6.7	32.7	40.2	17.8
1-3	0.5	2.7	8.4	36.6	38.1	13.7
	$\bar{x}$=0.4	$\bar{x}$=2.1	$\bar{x}$=5.9	$\bar{x}$=24.7	$\bar{x}$=28.7	$\bar{x}$=38.1
	SD=0.1	SD=0.65	SD=2.9	SD=17.3	SD=18.1	SD=38.8
2-1	0.3	0.7	2.3	18.7	16.4	61.6
2-2	0.5	1.0	3.4	16.3	10.8	68.0
2-3	0.4	1.1	3.6	15.9	11.0	68.0
	$\bar{x}$=0.4	$\bar{x}$=0.9	$\bar{x}$=3.1	$\bar{x}$=17.0	$\bar{x}$=12.7	$\bar{x}$=65.8
	SD=0.1	SD=0.2	SD=0.7	SD= 1.5	SD= 3.2	SD= 3.7
3-1	0.6	1.4	4.4	34.6	45.2	13.8
3-2	0.4	1.3	4.0	38.4	42.5	12.6
3-3	0.4	1.1	3.8	29.9	42.3	22.5
	$\bar{x}$=0.5	$\bar{x}$=1.3	$\bar{x}$=4.3	$\bar{x}$=34.3	$\bar{x}$=43.3	$\bar{x}$=16.3
	SD=0.1	SD=0.2	SD=0.5	SD= 4.3	SD= 1.6	SD= 5.4
4-1	5.1	5.9	3.7	30.0	33.9	21.4
4-2	8.8	17.1	14.2	14.4	6.3	39.2
4-3	10.0	22.2	18.2	34.4	13.3	1.9
	$\bar{x}$=8.0	$\bar{x}$=15.1	$\bar{x}$=12.0	$\bar{x}$=26.3	$\bar{x}$=17.8	$\bar{x}$=20.8
	SD=2.6	SD= 8.3	SD= 7.5	SD=10.5	SD=14.3	SD=18.6
5-1	0.2	0.7	2.3	16.4	45.1	35.3
5-2	0.2	0.6	1.7	14.6	38.0	44.9
5-3	0.1	0.3	0.8	4.8	26.4	67.6
	$\bar{x}$=0.2	$\bar{x}$=0.5	$\bar{x}$=1.6	$\bar{x}$=11.9	$\bar{x}$=36.5	$\bar{x}$=49.3
	SD=0.1	SD=0.2	SD=0.8	SD= 6.2	SD= 9.4	SD=16.6

APPENDIX III TABLE 1b PERCENT COMPOSITION OF PARTICLE SIZE FRACTIONS IN SEDIMENT SAMPLES COLLECTED AUGUST 6 AND 7, 1983 (continued)

SAMPLE NUMBER	PARTICLE SIZE (mm)					
	<.063	.063-.15	.15-.25	.25-.5	.5-1.0	>1.0
	SILT	V. FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL
6-1	0.7	1.6	2.9	7.3	11.1	76.4
6-2	1.2	1.1	2.3	7.7	15.4	72.3
6-3	0.7	1.0	2.0	7.0	13.3	76.0
	$\bar{x}$=0.9	$\bar{x}$=1.2	$\bar{x}$=2.4	$\bar{x}$=7.3	$\bar{x}$=13.3	$\bar{x}$=74.9
	SD=0.3	SD=0.3	SD=0.5	SD=0.4	SD= 2.2	SD= 2.3
7-1	1.8	2.2	3.4	12.6	14.3	65.8
7-2	1.2	3.9	7.2	12.0	6.4	69.3
7-3	1.1	1.5	2.6	10.8	14.5	69.5
	$\bar{x}$=1.4	$\bar{x}$=2.5	$\bar{x}$=4.4	$\bar{x}$=11.8	$\bar{x}$=11.7	$\bar{x}$=68.2
	SD=0.4	SD=1.2	SD=2.5	SD= 0.9	SD= 4.6	SD= 2.1
8-1	1.4	2.1	3.3	7.1	8.9	77.2
8-2	1.9	2.0	2.8	5.5	6.8	81.0
8-3	0.7	1.0	2.0	7.0	9.5	79.8
	$\bar{x}$=1.3	$\bar{x}$=1.7	$\bar{x}$=2.7	$\bar{x}$=6.5	$\bar{x}$=8.4	$\bar{x}$=79.3
	SD=0.6	SD=0.6	SD=0.7	SD=0.9	SD=1.4	SD= 1.9
9-1	2.2	5.0	7.9	32.6	25.6	26.7
9-2	1.2	2.8	3.9	17.0	16.5	58.6
9-3	0.9	1.6	3.0	14.0	13.6	66.9
	$\bar{x}$=1.4	$\bar{x}$=3.1	$\bar{x}$=4.9	$\bar{x}$=21.2	$\bar{x}$=18.6	$\bar{x}$=50.7
	SD=0.7	SD=1.7	SD=2.6	SD=10.0	SD= 6.3	SD=21.2
10-1	3.3	1.9	3.3	46.0	15.1	30.4
10-2	1.1	0.9	1.9	20.6	14.3	61.2
10-3	0.5	0.6	1.5	18.9	18.2	60.3
	$\bar{x}$=1.6	$\bar{x}$=1.1	$\bar{x}$=2.2	$\bar{x}$=28.5	$\bar{x}$=15.9	$\bar{x}$=50.6
	SD=1.5	SD=0.7	SD=0.9	SD=15.2	SD= 2.1	SD=17.5

APPENDIX III TABLE 2a CONCENTRATIONS OF OILS AND GREASE AND EXTRACTABLE METALS IN SEDIMENT SAMPLES COLLECTED FROM TRAIL RIVER ON AUGUST 6, 1982

SAMPLE NUMBER	Oils & Grease (mg/kg)	EXTRACTABLE METALS (mg/kg) Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
A-1	< 45	<5	10800	12.8	22.8	131	.6	120000	<.5	<1	20	14	17700	.3	3120
A-2	< 59	<5	13800	30	29.2	233	.7	124000	<.8	<2	30	24	20400	--	3500
A-3	< 53	<5	12100	30	24.5	152	.7	127000	<.7	<2	27	18	19000	--	3350
B-1	< 56	<5	11300	10	29.9	172	.6	120000	<.5	2	20	21	18600	.27	3120
B-2	< 49	<5	12800	30	21.3	203	.6	131000	<.5	<1	22	16.	20400	.28	3260
B-3	< 48	<5	11000	10	13.3	192	.6	126733	<.2	1.9	18.8	15.9	18300	.25	2590
C-1	86	<5	16500	14	20.8	299	.6	86300	<.3	8.6	27.1	21.6	23700	.65	3780
C-2	118	<5	16100	9	19.6	410	.6	86200	<.3	6	26.4	23.1	23900	.28	3480
C-3	94	<5	17800	12	36	398	.6	88300	<.3	7.3	28.4	23.1	24500	.3	4020

APPENDIX III TABLE 2a CONCENTRATIONS OF OILS AND GREASE AND EXTRACTABLE METALS IN SEDIMENT SAMPLES COLLECTED FROM TRAIL RIVER ON AUGUST 6, 1982 (continued)

SAMPLE NUMBER	Extractable Metals (mg/kg)												
	Mg	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
A-1	12600	316	2	5740	20	1180	8.	7790	<2	226	63.2	28	84.2
A-2	11600	398	<2	1370	12	1080	<8.	12400	<4	234	102	34	100
A-3	11900	371	2	1540	20	990	10	11100	6	238	85.7	32	84
B-1	11700	321	<1	840	17	1330	13	8430	<3	218	74.2	31	90.4
B-2	12300	362	1	470	16	1300	12	7890	<2	235	111	35	112
B-3	12000	335	1.7	410	17	1140	11	5640	<1	217	67.2	31	94.4
C-1	11500	656	<.8	310	25	1630	15	5080	<2	163	71.1	59	101
C-2	11400	683	<.8	290	22	1680	13	6260	<2	170	71.2	57	104
C-3	11500	686	<.8	330	24	1700	14	3730	<2	172	69.3	63	106

APPENDIX III TABLE 2b CONCENTRATIONS OF OILS AND GREASE AND EXTRACTABLE METALS IN SEDIMENT
SAMPLES COLLECTED AUGUST 6 AND 7, 1983

SAMPLE NUMBER	Oils & Grease (mg/kg)	EXTRACTABLE METALS (mg/kg) Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
1-1	<300	<.016	11300	14	167	.7	9340	<.3	11.1*	16.3	24.5	28500	.05	3220
1-2	<300	<.016	11000	6.0	150	.7	8620	1.5	13.3	15.9	24.4	28700	.05	3010
1-3	500	.065	12000	14*	148	.8	9390	<.3	12.7	16.8	26.1	30000	.05	3310
2-1	<300	.039	15700	12	303	.7	7950	<.3	11.6	28.5	25.1	28900	.12	3540
2-2	<300	.071	16600	10.3	349	.8	8830	<.3	10.8	32.7	25.6	28900	.12*	3740
2-3	<300	.060	14200	10.7	351	.7	8860	<.3	12.4	26.2	23.9	28900	.1	3130
3-1	<300	.024	10900	20	145	.7	33000	<.3	13.8*	17.6	28.1	26600	.34	3020
3-2	<300	.034	10400	20	151	.6	32100	0.4	15.4	16.3	26.4	26300	.3	3050
3-3	400	.034	11100	23	132	.6	31000	<.3	12.7	16.5	28.7	25400	.34	3230
4-1	<300	.08	17500	12	207	.7	28400	.6	11.6	28.3	22.2	28500	.09	3560
4-2	500	.072	16300	13	192	.7	23200	.3*	9.2*	26.4	21.2	27600	.09*	3350*
4-3	<300	.066	15700	17	176	.7	21800	.6	15.2	25.5	19.8	27100	.09	3290
5-1	<300	.069	10500	14.6	242	.6	140000	.6	8.4*	22.2	14.2	19400	.06	2380
5-2	<300	.08	11000	16	191	.7	133000	.6	2.7	21	13.7	18800	.06	2570
5-3	<300	.065	11600	27*	190	.7	132000	1	9.4	23.6	15.1	19300	.08	2620

* This is the mean value of 2 replicate measurements in which the range exceeded ± 10% of the mean.

APPENDIX III TABLE 2b CONCENTRATIONS OF OILS AND GREASE AND EXTRACTABLE METALS IN SEDIMENT SAMPLES COLLECTED AUGUST 6 AND 7, 1983 (continued)

SAMPLE NUMBER	Oils & Grease (mg/kg)	EXTRACTABLE METALS (mg/kg) Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
6-1	300	.13	17500	22	422	.8	65300	.8	13	33.2	26	29300	.11	3420
6-2	300	.13	18800	15	418	.9	58100	.7	13.2*	33.3	28.7	30200	.13	3650
6-3	<300	.1	18600	16	479	.9	58500	.8	9.4	31.9	25.9	29800	.12	3490
7-1	<300	.11	25800	14*	1300	1.1	52500	.4*	9.5	39.3	27.2	32300	.13	4360
7-2	400	.13	26900	9.5	479	1.2	41700	2.1	11.6	37.8	27.0	31500	.1	4850
7-3	<300	.14	25400	11.2	1510	1.1	47400	.5*	12.3*	39.9	30.6	34000	.13	4330
8-1	<300	.1	25100	15	306	1.1	10300	<.3	12.2	37.0	24.8	33900	.11	4480
8-2	<300	.1	24400	12.4	310	1	10300	.5	11.5*	36.6	25.2	32600	.12	4360
8-3	<300	.12	24600	14	398	1.1	10100	<.5	13.8	38.8	24.2	33500	.11	4130
9-1	<300	.037	22900	12	195	1	2250	<.3	13.8*	31.0	18.3	26300	.09*	4450
9-2	300	.061	21100	14	186	.9	2420	<.3	13.3	29.4	19.5	27300	.09	3780
9-3	<300	.064	24100	14.6	221	1	2520	.6	14.0	33.1	20.2	28500	.09	4470
10-1	<300	.048	22300	10	281	.7	3480	<.3	11.8	34.8	21.0	29200	.12	3510
10-2	<300	.048	20000	8.1	283	.6	3410	.5*	13.1	32.9	19.5	27900	.17*	3030
10-3	300	.043	17800	10	335	.6	3350	.9	15.0	31.3	18.3	28100	.08	2540

* This is the mean value of 2 replicate measurements in which the range exceeded ± 10% of the mean.

APPENDIX III TABLE 2b CONCENTRATIONS OF OILS AND GREASE AND EXTRACTABLE METALS IN SEDIMENT SAMPLES COLLECTED AUGUST 6 AND 7, 1983 (continued)

SAMPLE NUMBER	EXTRACTABLE METALS (mg/kg)												
	Mg	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
1-1	3360	585	<.8	170	24	399	17	3420	<2	60.4	34.1	20	76.1
1-2	3290	593	<.8	200	28	353	18	2930	<2	58	29.9	19	74.6
1-3	3430	628	<.8	160	26	381	19	3300	<2	63.3	34.4	20	77.7
2-1	4880	566	1.6	210	32	948	12	3600	2	39.4	110	51	108
2-2	5270	539	1.9*	210	31	960	14	3460	2*	43	113	53	106
2-3	5090	498	<.8	210	31	974	12	3600	5	41.6	118	47	105
3-1	5390	589	<.8	160	29	564	19	3310	<2	135	33.6	20	76
3-2	5170	566	1.3	160	30	564	19	3000	<2	130	33.1	18	74.8
3-3	5250	535	<.8	340	28	545	25*	2620*	3*	124	35.4	19	76
4-1	5990	822	<.8	310	31	1120	11	2720	<2	113	71.2	49	91.2
4-2	5930	749	<.8	260	28	1100	11	3200*	<2	97.9	60.7	45	86.1
4-3	5720	743	<.8	250	28	1070	11	3500	3	93.5	60.7	45	83.8
5-1	4400	307	1.5	260	24	1400	17	3140	2*	245	70.6	35 1	91.7
5-2	4000	327	1.7	240	20	1260	19	2910	3	235	73	35 1	99.2
5-3	3600	328	2.1*	380	26	1170	27	2450*	5	233	65.5	33 1	97.3

* This is the mean value of 2 replicate measurements in which the range exceeded ± 10% of the mean.

APPENDIX III TABLE 2b CONCENTRATIONS OF OILS AND GREASE AND EXTRACTABLE METALS IN SEDIMENT SAMPLES COLLECTED AUGUST 6 AND 7, 1983 (continued)

SAMPLE NUMBER	EXTRACTABLE METALS (mg/kg)												
	Mg	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Sr	Ti	V	Zn
6-1	10100	848	3.9	420	37	1400	18	3660	2	139	58.6	62	123
6-2	9520	828	1.4	410	37	1340	16	2960	<2	128	56.6	61	113
6-3	9940	796	1.5	420	31	1410	14	1880	<2	130	54.2	64	110
7-1	10100	225	<.8	510	39	1320	10	1570*	<2	116	30.8	55	124
7-2	9190	224	<.8	770	37	1090	9	2950	<2	91.6	34.6	53	127
7-3	9480	241	<.8	540	41	1270	11*	2960	<2	108	34.6	53	134
8-1	6720	479	2.6	430	37	1000	11	2660	2	42.2	34.3	56	116
8-2	6650	468	1.9	450	37	952	10*	1860	3	40.7	29.7	56	112
8-3	6620	451	1.9	470	39	977	13	1470	<2	41.4	26.3	57	122
9-1	3500	508	1.8*	330	30	644	7*	2280*	2*	23.7	30.2	59	90.4
9-2	3440	558	1.8	320	31	649	9	4040	3	23.5	30.6	54	94.9
9-3	3730	636	1.6*	410	34	680	13*	2890*	5*	25	29.2	61	99.6
10-1	5820	492	<.8	410	31	1040	3	1340	4	33.2	81.9	60	96.3
10-2	5230	556	<.8	300	32	1120	3	1500*	<2	33.8	87.9	56	93
10-3	4800	548	<.8	310	33	1160	7	3080	2	33.8	99.2	53	92.9

* This is the mean value of 2 replicate measurements in which the range exceeded ± 10% of the mean.

APPENDIX IV

BOTTOM FAUNA DATA

APPENDIX IV TABLE 1 TAXONOMIC LIST OF THE BENTHIC ORGANISMS COLLECTED (the numbers correspond to the organism referenced in Appendix IV, Table 2)

	Phylum / Class / Order / Family / Genus species
1.	Nematoda
	Annelida
	Oligochaeta
	Haplotaxida
2.	Tubificidae (with hair setae)
3.	Tubificidae (without hair setae)
4.	Enchytraeidae
	Lumbriculida
	Lumbriculidae
5.	*Kincaidiana hexatheca*
	Arthropoda
	Crustacea
	Subclass: Copepoda
	Eucopepoda
	Suborder: Cyclopoida
	Cyclopidae
6.	*Cyclops* sp.
	Suborder: Calanoida
	Diaptomidae
7.	*Diaptomus* sp. (*tyrelli*)
	Temoridae
8.	*Eurytemora* sp. (*affinis*)
	Amphipoda
	Suborder: Gammaridea
	Gammaridae
9.	*Synurella* n. sp.*
	Arachnoidea
10.	Acari

APPENDIX IV TABLE 1 TAXONOMIC LIST OF THE BENTHIC ORGANISMS COLLECTED (the numbers correspond to the organism referenced in Appendix IV, Table 2) (continued)

Insecta

Plecoptera

Nemouridae

11. *Podmosta* sp.

Capniidae

12. *Capnia* sp.

Perlodidae

13. *Arcynopteryx* sp.

Chloroperlidae

14. *Alloperla* sp.

Ephemeroptera

Heptageniidae

15. *Cinygmula* sp.

Baetidae

16. *Baetis* sp.

Siphlonuridae

17. *Ameletus* sp.

18. Hemiptera

Coleoptera

Haliplidae

19. *Haliplus* sp.

Dytiscidae

20. *Hydaticus* sp.

21. Staphylinidae (adult)

Diptera

Suborder: Nematocera

Tipulidae

22. *Dicranota* sp.

23. *Tipula* sp.

24. *Limnophila* sp.

Anohpeles sp. (adult)

APPENDIX IV TABLE 1 TAXONOMIC LIST OF THE BENTHIC ORGANISMS COLLECTED (the numbers correspond to the organism referenced in Appendix IV, Table 2) (continued)

Simuliidae

25. *Prosimullium* sp.
26. *Cnephia* sp.
27. *Simullium* sp.

28. Chironomidae
29. *Corynoneura* sp.
30. *Micropsectra* sp.
31. *Epoicocladius* sp.
32. *Eukiefferiella* sp.
33. *Heterotrissocladius* sp.
34. *Monodiamesa* sp.
35. *Cricotopus* sp.
36. *Cardiocladius* sp.
37. *Diamesa* sp.

Suborder: Brachycera

Dolichopodidae

38. *Paraphrosylus* sp. (?)

Empididae

39. *Weidemannia* sp.
40. *Hemerodromia* sp.
41. *Chelifera* sp.
Empididae sp. (adult)

Suborder: Cyclorrhapha

Muscidae (Anthomyiidae)

42. *Limnophora* sp.

Mollusca

Gastropoda

Mesogastropoda

Valvatidae

43. *Valvata* sp.

APPENDIX IV TABLE 2 BOTTOM FAUNA DATA

ORGANISM	STATION									
	1	2	3	4	5	6	7	8	9	10
1. Nematoda		1	2	3	3		1	1		9
2. Tubificidae w/hair setae	1	7	1	24			1	14	1	1
3. Tubificidae w/o hair setae						7	2	2		1
4. Enchytraeidae	2		33		10	42	5	15	26	43
5. Kincaidiana hexatheca	14	1	13					6	24	
6. Cyclops sp.							1			53
7. Diaptomus sp.								1		
8. Eurytemora sp.										9
9. Synurella n. sp.			4						309	
10. Acari	1									
11. Podmosta sp.	163	14	56	1	1	1	2		43	1
12. Capnia sp.	24	16	40	2	3		78	1	5	
13. Arcynopteryx sp.							14			
14. Alloperla sp.	2						1			
15. Cinygmula sp.	76	22	8	1	11	4	6		45	12
16. Baetis sp.	526	9	10	4	4	3	14	1	2	
17. Ameletus sp.						17		2		3
18. Hemiptera						9				
19. Haliplus sp.		3								
20. Hydaticus sp.			1	1	2	3				
21. Staphylinidae	1					5				
22. Dicranota sp.				1						
23. Tipula sp.	1	1	5						7	1
24. Limnophila sp.			1		1					5
25. Prosimulium sp.			1	1		1				
26. Cnephia sp.			1			4				
27. Simulium sp.		1								

APPENDIX IV TABLE 2 BOTTOM FAUNA DATA (continued)

ORGANISM	STATION									
	1	2	3	4	5	6	7	8	9	10
28. Chironomidae		2	1	35	8	5	9		1	1
29. Corynoneura sp.				3	1		1			
30. Micropsectra sp.										2
31. Epoicocladius sp.				1			2			
32. Eukiefferiella sp.	1	1		218	16	1	1			
33. Heterotrissocladius sp.	8	26	1	52	4		11		4	
34. Monodiamesa sp.	3	2	3	18			8			
35. Cricotopus sp.	3	15	2	297	67	1	33	1	2	
36. Cardiocladius sp.		1	5			7				
37. Diamesa sp.				4			9			
38. Paraphrosylus sp. (?)				8						
39. Waldemannia sp.			1							
40. Hemerodromia sp.				2						
41. Chelifera sp.				1						
42. Limnophora sp.	1			1						
43. Valvata sp.										1
Total Organisms (T)	827	122	189	678	131	110	199	44	469	142
Total at general Level (H)	822	112	152	616	110	42	181	12	441	87
Diversity Index (H')	0.49	0.89	0.83	0.56	0.59	0.80	0.81	0.64	0.90	0.58
Evenness (J')	0.44	0.80	0.69	0.45	0.59	0.74	0.71	0.82	0.94	0.61